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Rainbow Trout and Brook Trout Mortality from High Voltage AC Electrofishing in a Controlled Environment

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ABSTRACT

Twelve groups of 250 hatchery rainbow trout (*Salmo gairdneri*) and brook trout (*Salvelinus fontinalis*) were electroshocked in hatchery raceways and monitored for 15 days. The mean immediate, delayed, and total mortality was less than 2% at all alternating current voltages tested (350, 700, and 760 volts). Radiographs of surviving trout showed that only a small percentage (<3%) had dislocated or fractured vertebrae. Excessive delayed mortality from the use of high-voltage alternating current to sample trout populations in waters with low conductivity should be of little concern for most management activities.

Electrofishing is a standard sampling technique used in many trout streams (Vibert 1967). The extent of immediate and delayed mortality from electrofishing, however, has been a concern of fishery workers for years (Hauck 1949; Godfrey 1954; Collins et al. 1954; Pugh 1962; Bouck and Ball 1966). Delayed mortality could (1) bias population estimates (Pratt 1954), (2) limit spawning success (Maxfield et al. 1971; Marriott 1973), or (3) cause an unexplained or misinterpreted change in population level or structure.

In waters with moderate to high conductivity where low alternating current (AC) and/or direct current (DC) voltages are effective for stunning fish (Vibert 1967), mortality from electrofishing is negligible (Godfrey 1954; Horak and Klein 1967; Maxfield et al. 1971). However, many trout streams have a low conductivity and low AC or DC voltages are ineffective, except when salt blocks have been added to increase conductivity (Lennon and Parker 1958). Salt blocks are not practical, however, for remote areas with poor access. Because of the low conductivity of many trout streams in the southeastern United States, it is necessary to use high AC voltages (400–1,000) when electrofishing. However, the effects of high-voltage AC current on trout mortality has not been documented.

In this paper, I present data on (1) immediate mortality, (2) delayed mortality, and (3) vertebrae injuries in hatchery rainbow trout (*Salmo gairdneri*) and brook trout (*Salvelinus fontinalis*) following electrofishing with high AC voltages.

METHODS

Study Protocol

A completely randomized experimental design was used in this study. Nine experimental lots of 250 randomly selected hatchery fish (125 rainbow trout and 125 brook trout) were electrofished in hatchery raceways using 350, 700, and 760 volts (AC). Each treatment had 3 replications. An additional three experimental lots were used as controls and were not electrofished. Treatments and holding raceways were randomly assigned to experimental lots. After treatment, immediate mortality was noted and delayed mortality was monitored daily for 15 days. All dead fish were preserved for further examination. After 15 days, all living fish were examined for abnormalities (severe burns, irregular swimming). All "abnormal" fish and 24 "normal"-appearing fish from each treatment also were preserved. All preserved fish were later x-rayed in both a dorsal and lateral position to detect injured vertebrae.

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Experimental Conditions

The study was conducted at the North Carolina Wildlife Resources Commission's Balsam Fish Hatchery near Waynesville, North Carolina during December 1983. Water temperature (5.5 C) and conductivity (10 μmhos) during electrofishing were consistent with water conditions during the pre- and post-holding periods. All electrofishing took place in three outdoor concrete raceways (10.2 × 1.9 × 0.7 m). Fish were held in 1 of 12 indoor raceways after treatments at equal holding densities of 17 kg/m^3. Rainbow trout had a mean length of 203 mm (SE = 2.4) and a range of 157–262 mm. Brook trout were significantly smaller (Student's t test, $P < 0.05$, $N_1 = N_2 = 100$), with a mean length of 167 mm (SE = 2.6), and a range of 121–244 mm. All fish appeared to be healthy prior to electrofishing, had no history of disease, and were not fed during the experiment. The fish were transferred immediately to the holding raceways after the experimental lots were selected.

Electrofishing

Two-man crews electrofished each raceway three to four times in a manner similar to stream electrofishing until all fish were removed. Captured fish were immediately transferred to holding raceways to reduce handling stress.

The treatment with the lowest voltage was done with a backpack electroshocker having a maximum output of 350 v. A radio antenna served as one probe and an aluminum hoop (50 cm in diameter) with an attached net served as the end of the other probe. The unit was powered by a Weedeater SV-3 engine with a Tiny Tiger generator model 5001-1 (capacity 350 watts maximum, 250 watts continuous, voltage 110 AC, and a frequency of 300 hertz). The same equipment was used for the next treatment which had a maximum output of 700 v.

A backpack electroshocker with a maximum output of 760 v was used for the highest voltage. Aluminum hoops (25 cm in diameter) without nets served as the ends of the probes. The unit was powered by a TAS Portable Engine Generator (QEG 300, capacity 300 watts maximum, 250 watts continuous, voltage 110–115 AC, and a frequency of 250–300 hertz).

RESULTS

The immediate, delayed, and total mortalities were low with no significant differences (analysis of variance, $P > 0.05$, N = 12) among treatment means for rainbow trout and brook trout, or the combined data from both species (Table 1). Only 28 of the 3,000 fish in the experiment died—7 immediately after treatment and 21 later during a 15-day period. Rainbow trout had a significantly higher percentage of the mortalities (79%) than brook trout (Chi-square, $P < 0.05$, N = 28). The combined total mortality for both species averaged 0.0% (control), 1.8% (350 v), 1.3% (700 v), and 0.5% (760 v). There were no significant differences (t test, $P > 0.05$) in the mean length between either the living and dead rainbow trout ($N_1 = 100$, $N_2 = 22$) or brook trout ($N_1 = 100$, $N_2 = 6$). At the conclusion of the experiment, all fish were maintaining equilibrium with no apparent stress except for a few which exhibited abnormal swimming behavior.

Table 1. The mean number of mortalities (immediate, 15-day delayed, and total) for trout electroshocked by three AC voltages. Numbers given are the mean of 3 replications (125 rainbow trout (RBT) and 125 brook trout (BRK) per replication). Means were not significantly different (analysis of variance, $P >$ 0.05, N = 12).

Treatment	Mean number of mortalities						Percent mortality of all fish
	Immediate		Delayed		Total		
	RBT	BRK	RBT	BRK	RBT	BRK	
Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	1.0	0.0	3.0	0.6	4.0	0.6	1.8
700	1.0	0.0	2.0	0.3	3.0	0.3	1.3
760	0.0	0.3	1.0	0.0	1.0	0.3	0.5

The number of survivors with a visible abnormality (burn, erratic swimming style) was low, averaging 0.0% (control), 1.6% (350 v), 2.4% (700 v), and 0.8% (760 v). Between the two species, brook trout had a significantly higher percentage (72%) of abnormalities (Chi-square, $P < 0.05$, N = 36).

The radiographs showed that only 21% (6 of 28) of the dead trout had fractured or dislocated vertebrae. However, 77% (27 of 36) of the abnormal surviving fish had fractured or dislocated vertebrae, the injury usually occurring somewhere between the 15th and the 25th abdominal vertebrae (Figs. 1 and 2). Normal-appearing shocked fish had a 1% (1 of 96) level of injured vertebrae and the control fish had no injured vertebrae. Some fish from all treatments

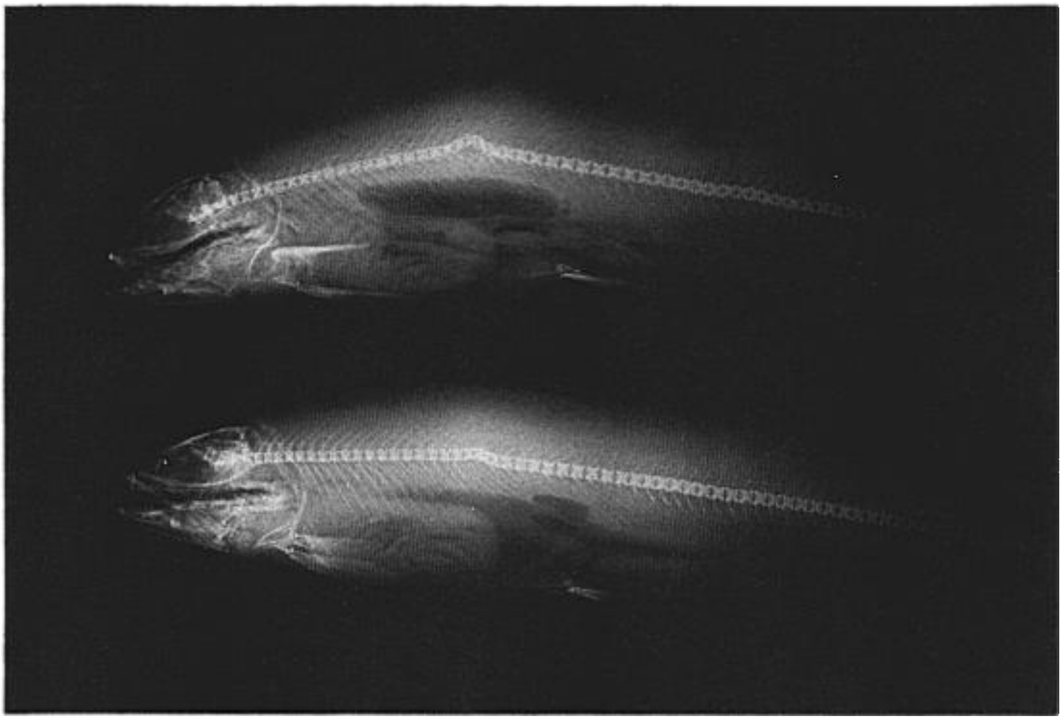

Figure 1. Radiograph of a lateral view of two brook trout that exhibited abnormal swimming styles after being electroshocked by 700 v AC. Note dislocated vertebrae.

had fused vertebrae which probably were not caused by electrofishing (McCrimmon and Bidgood 1965; Gill and Fisk 1965).

Management Implications

Under the test conditions, all the high-voltage treatments had a low percentage of mortalities (<2%) and abnormalities (<3%). Less than 5% of the fish were affected so that high-voltage electrofishing with alternating current probably is acceptable for most management uses in low conductivity water. However, the effects may be excessive for some research applications. Both managers and researchers should still use caution in electrofishing because different salmonid life stages and sizes may be more vulnerable to electroshock (Collins et al. 1954; Godfrey 1954; Marriott 1973). Also, the effects of electrofishing on many nongame species inhabiting trout streams is virtually unknown.

Species differences in the percentages of mortalities and abnormalities in this study may have been the result of size differences. Regardless of the reason, the differences probably were too small to be of management significance.

The reactions and representative symptoms of dead and dying fish were similar to those reported by Hauck (1949), and probably were caused by either respiration failure, hemorrhaging, fractured vertebrae, or the combined effects of trauma (Schreck et al. 1976).

The radiographs show that some of the surviving fish have suffered from the effects of electroshocking. I found more vertebrae injuries in surviving fish than in trout that had died. Because of the short duration of this study under artificial conditions, long-term implications of the burns and dislocated or fractured vertebrae on fish survival in the wild are not known. Horak and Klein (1967) burned, by electroshock, 39% of a group of rainbow trout but only 1% of the fish died after 5 weeks in a hatchery. Spencer (1967) found no correlation between mortality of bluegills (*Lepomis macrochirus*) and the incidence of injured vertebrae caused by electrofishing. Many of the injuries healed completely.

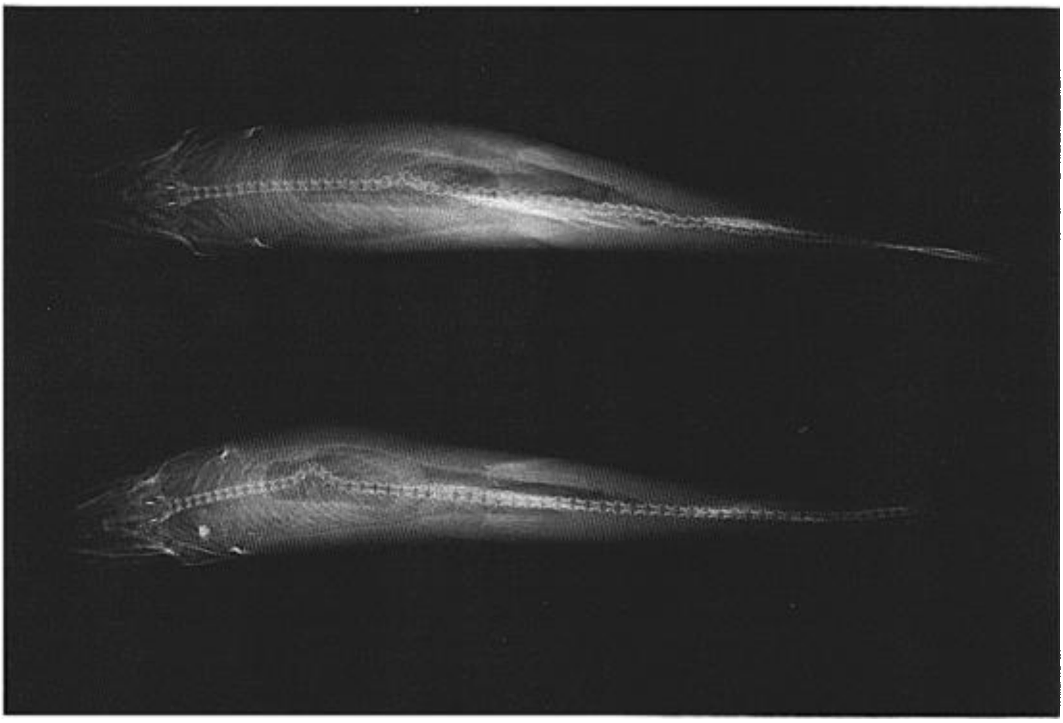

Figure 2. Radiograph of a dorsal view of two brook trout that exhibited abnormal swimming styles after being electroshocked by 700 v AC. Note dislocated vertebrae.

I believe fish were electroshocked and stunned more severely in this study than in typical field studies because of the confined area and lack of cover, but mortality may have been lower because of the minimal amount of handling. Extensive handling and holding (especially at warmer water temperatures) with or without the effects of electrofishing may be a more important mortality factor on trout than electrofishing alone.

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References

Bouck, G. R., and R. C. Ball. 1966. Influence of capture methods on blood characteristics on mortality in rainbow trout (*Salmo gairdneri*). Transactions of the American Fisheries Society 95:170–176.

Collins, G. B., C. D. Volz, and P. S. Trefethen. 1954. Mortality of salmon fingerlings exposed to pulsating direct current. U.S. Fish and Wildlife Service, Fishery Bulletin 92 56:61–81.

Gill, C. D., and D. M. Fisk. 1965. Vertebral abnormalities in sockeye, pink, and chum salmon. Transactions of the American Fisheries Society 87:177–182.

Godfrey, H. 1954. Mortalities among developing trout and salmon ova following shock by direct-current electrical fishing gear. Journal of the Fisheries Research Board of Canada 14:153–164.

Hauck, F. R. 1949. Some harmful effects of the electroshocker on large rainbow trout. Transactions of the American Fisheries Society 77:61–64.

Horak, D. L., and W. D. Klein. 1967. Influence of capture methods on fishing success, stamina, and mortality of rainbow trout (*Salmo gairdneri*) in Colorado. Transactions of the American Fisheries Society 96:220–222.

Lennon, R. E., and P. S. Parker. 1958. Applications of salt in electrofishing. Special Scientific Report-Fisheries 280. Bureau of Sport Fisheries and Wildlife, Washington, D.C.

MARRIOTT, R. A. 1973. Effects of electric shocking on fertility of mature pink salmon. The Progressive Fish-Culturist 35:191–194.

MAXFIELD, G. H., R. H. LANDER, AND K. L. LISCOM. 1971. Survival, growth, and fecundity of hatchery-reared trout after exposure to pulsating direct current. Transactions of the American Fisheries Society 100:546–552.

MCCRIMMON, H. R., AND B. BIDGOOD. 1965. Abnormal vertebrae in the rainbow trout with particular reference to electrofishing. Transactions of the American Fisheries Society 94:84–88.

PRATT, V. S. 1954. Fish mortality caused by electrical shockers. Transactions of the American Fisheries Society 84:93–96.

PUGH, J. R. 1962. Effect of certain electrical parameters and water resistivities on mortality of fingerling silver salmon. U.S. Fish and Wildlife Service, Fishery Bulletin 208 62:223–234.

SCHRECK, C. B., R. A. WHALEY, M. L. BASS, O. E. MAUGHAN, AND M. SOLAZZI. 1976. Physiological responses of rainbow trout (*Salmo gairdneri*) to electroshock. Journal of the Fisheries Research Board of Canada 33:76–84.

SPENCER, S. L. 1967. Internal injuries of largemouth bass and bluegills caused by electricity. The Progressive Fish-Culturist 33:168–169.

VIBERT, R., editor. 1967. Fishing with electricity; its applications to biology and management. Food and Agriculture Organization, United Nations, Fishing News (books) Ltd., London, England.